In The Specification:

Listed below is a clean copy of amended paragraphs of the Specification. A marked-up copy indicating the amended paragraphs of the Specification is provided in an accompanying document.

On page 14, please delete the paragraph beginning on line 4, and substitute therefor:

Controlling formation conditions to control the pressure of hydrogen in the produced fluid may result in improved qualities of the produced fluids. In some embodiments it may be desirable to control formation conditions so that the partial pressure of hydrogen in a produced fluid is greater than about 0.5 bars absolute, as measured at a production well.

On page 14, please delete the paragraph beginning on line 29, and substitute therefor:

In certain embodiments, a majority of the hydrocarbons in produced fluid may have a carbon number of less than approximately 25. Alternatively, less than about 15 weight % of the hydrocarbons in the fluid may have a carbon number greater than approximately 25. In other embodiments fluid produced may have a weight ratio of hydrocarbons having carbon numbers from 2 through 4, to methane, of greater than approximately greater than approximately 0.3. The non-condensable hydrocarbons may include, but are not limited to, hydrocarbons having carbon numbers less than 5.

On page 24, please delete the paragraph beginning on line 5, and substitute therefor:

FIGS. 3a-3c depict embodiments of heater wells;

On page 24, please delete the six paragraphs beginning on line 13, and substitute therefor:

FIG. 11 depicts a portion of an overburden of a formation with a natural distributed combustor heat source;

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FIG. 12 and FIG. 13 depict alternate embodiments of a natural distributed combustor heat source;

FIG. 14 and FIG. 15 depict embodiments of a natural distributed combustor system for heating a formation;

FIGS. 16-18 depict several embodiments of an insulated conductor heat source;

FIG. 19 depicts an embodiment of a conductor-in-conduit heat source in a formation;

FIG. 20 depicts an embodiment of a sliding connector;

FIG. 21 depicts an embodiment of a wellhead with a conductor-in-conduit heat source;

FIG. 22 and FIGS. 23a-23b depict several embodiments of a centralizer;

FIG. 24 depicts an alternate embodiment of a conductor-in-conduit heat source in a formation;

On page 27, please delete the paragraph beginning on line 15, and substitute therefor:

FIG. 104 depicts weight percent of a hydrocarbon produced from two laboratory experiments on coal from the field test site versus carbon number distribution;

On page 36, please delete the two paragraphs beginning on line 25, and substitute therefor:

Formation fluids including pyrolyzation fluids may be produced from the formation. The pyrolyzation fluids may include, but are not limited to, hydrocarbons, hydrogen, carbon dioxide, carbon monoxide, hydrogen sulfide, ammonia, nitrogen, water and mixtures thereof. As the temperature of the formation increases, the amount of condensable hydrocarbons in the produced formation fluid tends to decrease, and the formation will in many instances tend to produce mostly methane and hydrogen. If a coal formation is heated throughout an entire pyrolysis range, the formation may produce only small amounts of hydrogen towards an upper limit of the pyrolysis range. After all of the available hydrogen is depleted, a minimal amount of fluid production from the formation will typically occur.

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After pyrolysis of hydrocarbons, a large amount of carbon and some hydrogen may still be present in the formation. A significant portion of remaining carbon in the formation can be produced from the formation in the form of synthesis gas. Synthesis gas generation may take place during stage 3 heating as shown in FIG. 1. Stage 3 may include heating a coal formation to a temperature sufficient to allow synthesis gas generation. For example, synthesis gas may be produced within a temperature range from about 400 °C to about 1200 °C. The temperature of the formation when the synthesis gas generating fluid is introduced to the formation will in many instances determine the composition of synthesis gas produced within the formation. If a synthesis gas generating fluid is introduced into a formation at a temperature sufficient to allow synthesis gas generation, then synthesis gas may be generated within the formation. The generated synthesis gas may be removed from the formation. A large volume of synthesis gas may be produced during generation of synthesis gas.

On page 38, please delete the paragraph beginning on line 8, and substitute therefor:

A van Krevelen diagram may be useful for selecting a resource for practicing various embodiments described herein (see discussion below). Treating a formation containing kerogen in region 5 will in many instances produce, e.g., carbon dioxide, non-condensable hydrocarbons, hydrogen, and water, along with a relatively small amount of condensable hydrocarbons. Treating a formation containing kerogen in region 7 will in many instances produce, e.g., carbon, condensable and non-condensable hydrocarbons, carbon dioxide, hydrogen, and water. Treating a formation containing kerogen in region 9 will in many instances produce, e.g., methane and hydrogen. A formation containing kerogen in region 7, for example, may in many instances be selected for treatment because doing so will tend to produce larger quantities of valuable hydrocarbons, and lower quantities of undesirable products such as carbon dioxide and water, since the region 7 kerogen has already undergone dehydration and/or decarboxylation over geological time. In addition, region 7 kerogen can also be further treated to make other useful

products (e.g., methane, hydrogen, and/or synthesis gas) as such kerogen transforms to region 9 kerogen.

On page 39, please delete the paragraph beginning on line 23, and substitute therefor:

Kerogen in region 9 may be treated to generate methane and hydrogen. For example, if such kerogen was previously treated (e.g., it was previously region 7 kerogen), then after pyrolysis, longer hydrocarbon chains of the hydrocarbons may have already cracked and been produced from the formation. Carbon and hydrogen, however, may still be present in the formation.

On page 47, please delete the paragraph beginning on line 1, and substitute therefor:

Dewatering wells 110 may be placed in one or more rings surrounding selected portions of the formation. New dewatering wells may need to be installed as an area being treated by the in situ conversion process expands. An outermost row of dewatering wells may inhibit a significant amount of water from flowing into the portion of formation that is heated or to be heated. Water produced from the outermost row of dewatering wells should be substantially clean, and may require little or no treatment before being released. An innermost row of dewatering wells may inhibit water that bypasses the outermost row from flowing into the portion of formation that is heated or to be heated. The innermost row of dewatering wells may also inhibit outward migration of vapor from a heated portion of the formation into surrounding portions of the formation. Water produced by the innermost row of dewatering wells may include some hydrocarbons. The water may need to be treated before being released. Alternately, water with hydrocarbons may be stored and used to produce synthesis gas from a portion of the formation during a synthesis gas phase of the in situ conversion process. The dewatering wells may reduce heat loss to surrounding portions of the formation, may increase production of vapors from the heated portion, and may inhibit contamination of a water table proximate the heated portion of the formation.

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On page 49, please delete the paragraph beginning on line 1, and substitute therefor:

In certain embodiments a first portion of a heater well may extend from a surface of the ground, through an overburden, and into a coal formation. A second portion of the heater well may include one or more heater wells in the coal formation. The one or more heater wells may be disposed within the coal formation at various angles. In some embodiments, at least one of the heater wells may be disposed substantially parallel to a boundary of the coal formation. In alternate embodiments, at least one of the heater wells may be substantially perpendicular to the coal formation. In addition, one of the one or more heater wells may be positioned at an angle between perpendicular and parallel to a layer in the formation.

On page 52, please delete the two paragraphs beginning on line 17, and substitute therefor:

In some embodiments, a plurality of heated portions may exist within a unit of heat sources. A unit of heat sources refers to a minimal number of heat sources that form a template that may be repeated to create a pattern of heat sources within the formation. The heat sources may be located within the formation such that superposition (overlapping) of heat produced from the heat sources is effective. For example, as illustrated in FIG. 7, transfer of heat from two or more heat sources 330 results in superposition of heat 332 to be effective within an area defined by the unit of heat sources. Superposition may also be effective within an interior of a region defined by two, three, four, five, six, or more heat sources. For example, an area in which superposition of heat 332 is effective includes an area to which significant heat is transferred by two or more heat sources of the unit of heat sources. An area in which superposition of heat is effective may vary depending upon, for example, the spacings between heat sources.

Superposition of heat may increase a temperature in at least a portion of the formation to a temperature sufficient for pyrolysis of hydrocarbon within the portion. In this manner,

superposition of heat 332 tends to increase the amount of hydrocarbons in a formation that may be pyrolyzed. As such, a plurality of areas that are within a pyrolysis temperature range may exist within the unit of heat sources. The selected sections 334 may include areas in a pyrolysis temperature range due to heat transfer from only one heat source, as well as areas in a pyrolysis temperature range due to superposition of heat.

On page 54, please delete the paragraph beginning on line 1, and substitute therefor:

Because permeability and/or porosity increases in the heated formation, produced vapors may flow considerable distances through the formation with relatively little pressure differential. Therefore, in some embodiments, production wells may be provided near an upper surface of the formation. Increases in permeability may result from a reduction of mass of the heated portion due to vaporization of water, removal of hydrocarbons, and/or creation of fractures. In this manner, fluids may more easily flow through the heated portion.

On page 56, please delete the paragraph beginning on line 8, and substitute therefor:

A distance from a node of a polygon to a centroid of the polygon is smallest for a 3 sided polygon and increases with increasing number of sides of the polygon. The distance from a node to the centroid for an equilateral triangle is (length/2)/(square root(3)/2) or 0.5774 times the length. For a square, the distance from a node to the centroid is (length/2)/(square root(2)/2) or 0.7071 times the length. For a hexagon, the distance from a node to the centroid is (length/2)/(1/2) or the length. The difference in distance between a heat source and a midpoint to a second heat source (length/2) and the distance from a heat source to the centroid for an equilateral pattern (0.5774 times the length) is significantly less for the equilateral triangle pattern than for any higher order polygon pattern. The small difference means that superposition of heat may develop more rapidly and that the formation between heat sources may rise to a substantially more uniform temperature using an equilateral triangle pattern rather than a higher order polygon pattern.

On page 58, please delete the paragraph beginning on line 28, and substitute therefor:

For certain thinner formations, heating wells may be placed closer to an edge of the formation (e.g., in a staggered line instead of a line placed in the center of the layer) of the formation to increase the amount of hydrocarbons produced per unit of energy input. A portion of input heating energy may heat non-hydrocarbon containing formation, but the staggered pattern may allow superposition of heat to heat a majority of the coal formation to pyrolysis temperatures. If the thin formation is heated by placing one or more heater wells in the formation along a center of the thickness, a significant portion of the coal formation may not be heated to pyrolysis temperatures. In some embodiments, placing heater wells closer to an edge of the formation may increase the volume of formation undergoing pyrolysis per unit of energy input.

On page 76, please delete the paragraph beginning on line 10, and substitute therefor:

In certain embodiments, insulated conductor heaters may be placed in wellbores without support members and/or centralizers. This can be accomplished for heaters if the insulated conductor has a suitable combination of temperature and corrosion resistance, creep strength, length, thickness (diameter) and metallurgy that will inhibit failure of the insulated conductor during use. In an embodiment, insulated conductors that are heated to a working temperature of about 700 °C are less than about 150 meters in length, are made of 310 stainless steel, and may be used without support members.

On page 89, please delete the paragraph beginning on line 8, and substitute therefor:

In an embodiment, a control system may be configured to control electrical power supplied to an insulated conductor heater. Power supplied to the insulated conductor heater may be controlled with any appropriate type of controller. For alternating current, the controller may, for example, be a tapped transformer. Alternatively, the controller may be a zero crossover

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electrical heater firing SCR (silicon controlled rectifier) controller. Zero crossover electrical heater firing control may be achieved by allowing full supply voltage to the insulated conductor heater to pass through the insulated conductor heater for a specific number of cycles, starting at the "crossover," where an instantaneous voltage may be zero, continuing for a specific number of complete cycles, and discontinuing when the instantaneous voltage again may cross zero. A specific number of cycles may be blocked, allowing control of the heat output by the insulated conductor heater. For example, the control system may be arranged to block fifteen and/or twenty cycles out of each sixty cycles that may be supplied by a standard 60 Hz alternating current power supply. Zero crossover firing control may be advantageously used with materials having low temperature coefficient materials. Zero crossover firing control may substantially inhibit current spikes from occurring in an insulated conductor heater.

On page 90, please delete the paragraph beginning on line 22, and subsitute therefor:

As depicted in FIG. 20, sliding connector 583 may couple an end of conductor 580 disposed proximate a lowermost surface of conduit 582. Sliding connector 583 allows for differential thermal expansion between conductor 580 and conduit 582. Sliding connector 583 is attached to a conductor 580 located at the bottom of the well at a low resistance section 584 which may have a greater cross-sectional area. The lower resistance of section 584 allows the sliding connector to operate at temperatures no greater than about 90 °C. In this manner, corrosion of the sliding connector components is minimized and therefore contact resistance between sliding connector 583 and conduit 582 is also minimized. Sliding connector 583 may be configured as shown in FIG. 20 and as described in any of the embodiments herein. The substantially low resistance section 584 of the conductor 580 may couple conductor 580 to wellhead 690 as depicted in FIG. 19. Wellhead 690 may be configured as shown in FIG. 21 and as described in any of the embodiments herein. Electrical current may be applied to conductor 580 from power cable 585 through a low resistance section 584 of the conductor 580. As depicted in FIG. 19, electrical current may pass from conductor 580 through sliding connector

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583 to conduit 582. Conduit 582 may be electrically insulated from overburden casing 541 and from wellhead 690 to return electrical current to power cable 585. Heat may be generated in conductor 580 and conduit 582. The generated heat may radiate within conduit 582 and opening 514 to heat at least a portion of formation 516. As an example, a voltage of about 330 volts and a current of about 795 amps may be supplied to conductor 580 and conduit 582 in a 229 m (750 ft) heated section to generate about 1150 watts/meter of conductor 580 and conduit 582.

On page 100, please delete the paragraph beginning on line 14, and substitute therefor:

An elongated member may have a length of about 650 meters. Longer lengths may be achieved using sections of high strength alloys, but such elongated members may be expensive. In some embodiments, an elongated member may be supported by a plate in a wellhead. The elongated member may include sections of different conductive materials that are welded together end-to-end. A large amount of electrically conductive weld material may be used to couple the separate sections together to increase strength of the resulting member and to provide a path for electricity to flow that will not result in arcing and/or corrosion at the welded connections. The different conductive materials may include alloys with a high creep resistance. The sections of different conductive materials may have varying diameters to ensure uniform heating along the elongated member. A first metal that has a higher creep resistance than a second metal typically has a higher resistivity than the second metal. The difference in resistivities may allow a section of larger cross sectional area, more creep resistant, first metal to dissipate the same amount of heat as a section of smaller cross sectional area, second metal. The cross sectional areas of the two different metals may be tailored to result in substantially the same amount of heat dissipation in two welded together sections of the metals. The conductive materials may include, but are not limited to, 617 Inconel, HR-120, 316 stainless steel, and 304 stainless steel. For example, an elongated member may have a 60 meter section of 617 Inconel, 60 meter section of HR-120, and 150 meter section of 304 stainless steel. In addition, the elongated member may have a low resistance section that may run from the wellhead through the

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overburden. This low resistance section may decrease the heating within the formation from the wellhead through the overburden. The low resistance section may be the result of, for example, choosing a substantially electrically conductive material and/or increasing the cross-sectional area available for electrical conduction.

On page 106, please delete the paragraph beginning on line 24, and substitute therefor:

Inner conduit 612 may be configured to provide oxidation products 613 into outer conduit 615 proximate a bottom of opening 614. Inner conduit 612 may have insulation 612a. FIG. 27 illustrates an embodiment of inner conduit 612 with insulation 612a and ceramic insulator 612b disposed on an inner surface of inner conduit 612. Insulation 612a may be configured to substantially inhibit heat transfer between fluids in inner conduit 612 and fluids in outer conduit 615. A thickness of insulation 612a may be varied along a length of inner conduit 612 such that heat transfer to formation 516 may vary along the length of inner conduit 612. For example, a thickness of insulation 612a may be tapered from a larger thickness to a lesser thickness from a top portion to a bottom portion, respectively, of inner conduit 612 in opening 614. Such a tapered thickness may provide substantially more uniform heating of formation 516 along the length of inner conduit 612 in opening 614. Insulation 612a may include ceramic and metal materials. Oxidation products 613 may return to surface 550 through outer conduit 615. Outer conduit may have insulation 615a as depicted in FIG. 26. Insulation 615a may be configured to substantially inhibit heat transfer from outer conduit 615 to overburden 540.

On page 128, please delete the paragraph beginning on line 21, and substitute therefor:

The non-condensable hydrocarbons of fluid produced from a coal formation may have a H_2 content of greater than about 5 % by weight, greater than about 10 % by weight, or even greater than about 15 % by weight. The H_2 may be used, for example, as a fuel for a fuel cell, to hydrogenate hydrocarbon fluids in situ, and/or to hydrogenate hydrocarbon fluids ex situ. In addition, presence of H_2 within a formation fluid in a heated section of a coal formation is

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believed to increase the quality of produced fluids. In certain embodiments, the hydrogen to carbon atomic ratio of a produced fluid may be at least approximately 1.7 or above. For example, the hydrogen to carbon atomic ratio of a produced fluid may be approximately 1.8, approximately 1.9, or greater.

On page 135, please delete the paragraph beginning on line 21, and substitute therefor:

Thermal diffusivity within a coal formation may vary depending on, for example, a density of the coal formation, a heat capacity of the formation, and a thermal conductivity of the formation. As pyrolysis occurs within a selected section, the coal mass may be removed from the selected section. The removal of mass may include, but is not limited to, removal of water and a transformation of hydrocarbons to formation fluids. For example, a lower thermal conductivity may be expected as water is removed from a coal formation. This effect may vary significantly at different depths. At greater depths a lithostatic pressure may be higher, and may close certain openings (e.g., cleats and/or fractures) in the coal. The closure of the coal openings may increase a thermal conductivity of the coal. In some embodiments, a higher thermal conductivity may be observed due to a higher lithostatic pressure.

On page 138, please delete the paragraph beginning on line 1, and substitute therefor:

Substantially uniform heating of the coal formation may result in a substantially uniform increase in permeability. For example, uniformly heating may generate a series of substantially uniform fractures within the heated portion due to thermal stresses generated in the formation. Heating substantially uniformly may generate pyrolysis fluids from the portion in a substantially homogeneous manner. Water removed due to vaporization and production may result in increased permeability of the heated portion. In addition to creating fractures due to thermal stresses, fractures may also be generated due to fluid pressure increase. As fluids are generated within the heated portion, a fluid pressure within the heated portion may also increase. As the fluid pressure approaches a lithostatic pressure of the heated portion, fractures may be generated.

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Substantially uniform heating and homogeneous generation of fluids may generate substantially uniform fractures within the heated portion. In some embodiments, a permeability of a heated section of a coal formation may not vary by more than a factor of about 10.

On page 142, please delete the paragraph beginning on line 8, and substitute therefor:

Synthesis gas may be produced from a dipping formation from wells used during pyrolysis of the formation. As shown in FIG. 4, synthesis gas production wells 206 may be located above and down dip from an injection well 202. Hot synthesis gas producing fluid may be introduced into injection well 202. Hot synthesis gas fluid that moves down dip may generate synthesis gas that is produced through synthesis gas production wells 206. Synthesis gas generating fluid that moves up dip may generate synthesis gas in a portion of the formation that is at synthesis gas generating temperatures. A portion of the synthesis gas generating fluid and generated synthesis gas that moves up dip above the portion of the formation at synthesis gas generating temperatures may heat adjacent portions of the formation. The synthesis gas generating fluid that moves up dip may condense, heat adjacent portions of formation, and flow downwards towards or into a portion of the formation at synthesis gas generating temperature. The synthesis gas generating fluid may then generate additional synthesis gas.

On page 149, please delete the paragraph beginning on line 8, and substitute therefor:

The first temperature may be substantially different than the second temperature. Alternatively, the first and second temperatures may be approximately the same temperature. For example, a temperature sufficient to allow generation of synthesis gas having different compositions may vary depending on compositions of the first and second portions and/or prior pyrolysis of hydrocarbons within the first and second portions. The first synthesis gas generating fluid may have substantially the same composition as the second synthesis gas generating fluid. Alternatively, the first synthesis gas generating fluid may have a different composition than the second synthesis gas generating fluid. Appropriate first and second synthesis gas generating

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fluids may vary depending upon, for example, temperatures of the first and second portions, compositions of the first and second portions, and prior pyrolysis of hydrocarbons within the first and second portions.

On page 165, please delete the paragraph beginning on line 4, and substitute therefor:

FIG. 43 illustrates an embodiment of a method for preparing a nitrogen stream for an ammonia and urea process. Air 2060 may be injected into hot carbon containing formation 2062 to produce carbon dioxide by oxidation of carbon in the formation. In an embodiment, a heater may be configured to heat at least a portion of the carbon containing formation to a temperature sufficient to support oxidation of the carbon. The temperature sufficient to support oxidation may be, for example, about 260 °C for coal. Stream 2064 exiting the hot formation may be composed substantially of carbon dioxide and nitrogen. Nitrogen may be separated from carbon dioxide by passing the stream through cold spent carbon containing formation 2066. Carbon dioxide may be preferentially adsorbed versus nitrogen in the cold spent formation 2066. For example, at 50 °C and 0.35 bars, the adsorption of carbon dioxide on a spent portion of coal may be about 72 m^3/metric ton compared to about 15.4 m^3/metric ton for nitrogen. Nitrogen 2068 exiting the cold spent portion 2066 may be supplied to ammonia production facility 2070 with H_2 stream 2072 to produce ammonia 2074. The H_2 stream may be obtained by methods disclosed herein, for example, the methods described in FIGS. 41 and 42.

On page 176, please delete the paragraph beginning on line 5, and substitute therefor:

FIG. 60 illustrates an embodiment of an additional processing unit that may be included in surface facilities 2800 such as the facilities depicted in FIG. 58. Air 2903 may be fed to air separation unit 2900. Air separation unit 2900 may be configured to generate nitrogen stream 2902 and oxygen stream 2905. Oxygen stream 2905 and steam 2904 may be injected into exhausted coal resource 2906 to generate synthesis gas 2907. Produced synthesis gas 2907 may be provided to Shell Middle Distillates process unit 2910 that may be configured to produce

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middle distillates 2912. In addition, produced synthesis gas 2907 may be provided to catalytic methanation process unit 2914 that may be configured to produce natural gas 2916. Produced synthesis gas 2907 may also be provided to methanol production unit 2918 to produce methanol 2920. Furthermore, produced synthesis gas 2907 may be provided to process unit 2922 for production of ammonia and/or urea 2924, and fuel cell 2926 that may be configured to produce electricity 2928. Synthesis gas 2907 may also be routed to power generation unit 2930, such as a turbine or combustor, to produce electricity 2932.

On page 194, please delete the two paragraphs beginning on line 1, and substitute therefor:

Hydrocarbon fluids were produced from a portion of a coal formation by an in situ experiment conducted in a portion of a coal formation. The coal was high volatile bituminous C coal. It was heated with electrical heaters. FIG. 98 illustrates a cross-sectional view of the in situ experimental field test system. As shown in FIG. 98, the experimental field test system included at least coal formation 3802 within the ground and grout wall 3800. Coal formation 3802 dipped at an angle of approximately 36° with a thickness of approximately 4.9 meters. FIG. 99 illustrates a location of heat sources 3804a, 3804b, 3804c, production wells 3806a, 3806b, and temperature observation wells 3808a, 3808b, 3808c, 3808d used for the experimental field test system. The three heat sources were disposed in a triangular configuration. Production well 3806a was located proximate a center of the heat source pattern and equidistant from each of the heat sources. A second production well 3806b was located outside the heat source pattern and spaced equidistant from the two closest heat sources. Grout wall 3800 was formed around the heat source pattern and the production wells. The grout wall may include pillars 1-24. Grout wall 3800 was configured to inhibit an influx of water into the portion during the in situ experiment. In addition, grout wall 3800 was configured to substantially inhibit loss of generated hydrocarbon fluids to an unheated portion of the formation.

Temperatures were measured at various times during the experiment at each of four temperature observation wells 3808a, 3808b, 3808c, 3808d located within and outside of the heat source pattern as illustrated in FIG. 99. The temperatures measured (in degrees Celsius) at each of the temperature observation wells are displayed in FIG. 100 as a function of time. Temperatures at observation wells 3808a (3820), 3808b (3822), and 3808c (3824) were relatively close to each other. A temperature at temperature observation well 3808d (3826) was significantly colder. This temperature observation well was located outside of the heater well triangle illustrated in FIG. 99. This data demonstrates that in zones where there was little superposition of heat, temperatures were significantly lower. FIG. 101 illustrates temperature profiles measured at the heat sources 3804a (3830), 3804b (3832), and 3804c (3834). The temperature profiles were relatively uniform at the heat sources.

On page 195, please delete the paragraph beginning on line 14, and substitute therefor:

Table 5 illustrates the results from analyzing coal before and after it was treated (including heating to the temperatures as set forth in FIG. 101 (i.e., after pyrolysis and production of synthesis gas)) as described above. The coal was cored at about 11-11.3 meters from the surface, midway into the coal bed, in both the "before treatment" and "after treatment" examples. Both cores were taken at about the same location. Both cores were taken at about 0.66 meters from well 3804c (between the grout wall and well 3804c) in FIG. 99. In the following Table 5 "FA" means Fischer Assay, "as rec'd" means the sample was tested as it was received and without any further treatment, "Py-Water" means the water produced during pyrolysis, "H/C Atomic Ratio" means the atomic ratio of hydrogen to carbon, "daf" means "dry ash free," "dmmf" means "dry mineral matter free," and "mmf" means "mineral matter free." The specific gravity of the "after treatment" core sample was approximately 0.85 whereas the specific gravity of the "before treatment" core sample was approximately 1.35.

On page 199, please delete the paragraph beginning on line 13, and substitute therefor:

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FIG. 108 illustrates weight percentages of various carbon numbers products removed from high volatile bituminous "C" coal when coal is heated at various heating rates. Data points were derived from laboratory experiments and a Fischer assay. Curves for heating at a rate of 2 °C/day 3870, 3 °C/day 3872, 5 °C/day 3874, and 10 °C/day 3876 provided for similar carbon number distributions in the produced fluids. A coal sample was also heated in a Fischer assay test at a rate of about 17,100 °C/day. The data from the Fischer assay test is indicated by reference numeral 3878. Slow heating rates resulted in less production of components having carbon numbers greater than 20 as compared to the Fischer assay results 3878. Lower heating rates also produced higher weight percentages of components with carbon numbers less than 20. The lower heating rates produced large amounts of components having carbon numbers near 12. A peak in carbon number distribution near 12 is typical of the in situ conversion process for coal and oil shale.

On page 200, please delete the paragraph beginning on line 19, and substitute therefor:

Synthesis gas was also produced in an in situ experiment from the portion of the coal formation shown in FIG. 98 and FIG. 99. In this experiment, heater wells were also configured to inject fluids. FIG. 110 is a plot of weight of produced volatiles (oil and noncondensable gas) in kilograms as a function of cumulative energy input in kilowatt hours with regard to the in situ experimental field test. The figure illustrates the quantity and energy content of pyrolysis fluids and synthesis gas produced from the formation.

On page 201, please delete the paragraph beginning on line 28, and substitute therefor:

FIG. 114 illustrates production rate of synthesis gas (m³/min) as a function of steam injection rate (kg/h) in a coal formation. Data 3930 for a first run corresponds to injection at producer well 3806a in FIG. 99, and production of synthesis gas at heater wells 3804a, 3804b, and 3804c. Data 3932 for a second run corresponds to injection of steam at heater well 3804c, and production of additional gas at a production well 3806a. Data 3930 for the first run

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corresponds to the data shown in FIG. 113. As shown in FIG. 114, the injected water is in reaction equilibrium with the formation to about 2.7 kg/h of injected water. The second run results in substantially the same amount of additional synthesis gas produced, shown by data 3932, as the first run to about 1.2 kg/h of injected steam. At about 1.2 kg/h, data 3930 starts to deviate from equilibrium conditions because the residence time is insufficient for the additional water to react with the coal. As temperature is increased, a greater amount of additional synthesis gas is produced for a given injected water rate. The reason is that at higher temperatures the reaction rate and conversion of water into synthesis gas increases.

On page 203, please delete the paragraph beginning on line 7, and substitute therefor:

FIG. 117 is a plot that illustrates the effect of propane injection into a heated coal formation in the experimental field test. Propane was injected into production wells 3806a and 3806b and fluid was produced from heater wells 3804a, 3804b, and 3804c. The average temperatures measured at various wells were as follows: 3804a (737 °C), 3804b (753 °C), 3804c (726 °C), 3808a (589 °C), 3808b (573 °C), 3808c (606 °C), and 3806a (769 °C). When propane contacted the formation, it cracked to produce H_2, methane, ethane, ethene, propylene and coke. FIG. 117 shows that as the propane injection rate increased, the production of H_2 3960, methane 3962, ethane 3964, ethene 3966, propane 3968, and propylene 3969 increased. This indicates that propane is cracking to form H_2 and lower molecular weight components.

On page 205, please delete the paragraph beginning on line 26, and substitute therefor:

FIG. 122 is a plot of calculated equilibrium wet mole fractions for a coal reaction with water. Equilibrium wet mole fractions are shown for water 4006, H_2 4008, carbon monoxide 4010, and carbon dioxide 4012 as a function of temperature at a pressure of 2 bar absolute. At 390 °C, the produced gas includes about 89 % water, about 7 % H_2, and about 4 % carbon dioxide. At 500 °C, the produced gas includes about 66 % water, about 22 % H_2, about 11 % carbon dioxide, and about 1 % carbon monoxide. At 700 °C, the produced gas includes about

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percent 18 % water, about 47.5 % H_2, about 12 % carbon dioxide, and about 22.5 % carbon monoxide.

On page 207, please delete the three paragraphs beginning on line 1, and substitute therefor:

In the embodiments in FIGS. 124-126 the methane reactions in Equations (4) and (5) are included. The calculations set forth herein assume that char is only made of carbon and that there is an excess of carbon to steam. About 890 MW of energy 4024 is required to pyrolyze about 105,800 metric tons per day of coal. The pyrolysis products 4028 include liquids and gases with a production of 23,000 cubic meters per day. The pyrolysis process also produces about 7,160 metric tons per day of water 4030. In the synthesis gas stage about 57,800 metric tons per day of char with injection of 23,000 metric tons per day of steam 4032 and 2,000 MW of energy 4034 with a 20% conversion will produce 12,700 cubic meters equivalent oil per day of synthesis gas 4038.

FIG. 124 is an example of a low temperature in situ synthesis gas production that occurs at a temperature of about 450 °C with heat and mass balances in a coal formation that was previously pyrolyzed. A total of about 42,900 metric tons per day of water is injected into formation 4100 which may be char. FIG. 124 illustrates that a portion of water 4102 at 25 °C is injected directly into the formation 4100. A portion of water 4102 is converted into steam 4104 at a temperature of about 130 °C and a pressure at about 3 bars absolute using about 1227 MW of energy 4106 and injected into formation 4100. A portion of the remaining steam may be converted into steam 4108 at a temperature of about 450 °C and a pressure at about 3 bars absolute using about 318 MW of energy 4110. The synthesis gas production involves about 23% conversion of 13,137 metric tons per day of char to produce 56.6 millions of cubic meters per day of synthesis gas with an energy content of 5,230 MW. About 238 MW of energy 4112 is supplied to formation 4100 to account for the endothermic heat of reaction of the synthesis gas

reaction. The product stream 4114 of the synthesis gas reaction includes 29,470 metric tons per day of water at 46 volume percent, 501 metric tons per day carbon monoxide at 0.7 volume percent, 540 tons per day H_2 at 10.7 volume percent, 26,455 metric tons per day carbon dioxide at 23.8 volume percent, and 7,610 metric tons per day methane at 18.8 volume percent.

FIG. 125 is an example of a high temperature in situ synthesis gas production that occurs at a temperature of about 650 °C with heat and mass balances in a coal formation that was previously pyrolyzed. A total of about 34,352 metric tons per day of water is injected into formation 4200. FIG. 125 illustrates that a portion of water 4202 at 25 °C is injected directly into formation 4200. A portion of water 4202 is converted into steam 4204 at a temperature of about 130 °C and a pressure at about 3 bars absolute using about 982 MW of energy 4206, and injected into formation 4200. A portion of the remaining steam is converted into steam 4208 at a temperature of about 650 °C and a pressure at about 3 bars absolute using about 413 MW of energy 4210. The synthesis gas production involves about 22% conversion of 12,771 metric tons per day of char to produce 56.6 millions of cubic meters per day of synthesis gas with an energy content of 5,699 MW. About 898 MW of energy 4212 is supplied to formation 4200 to account for the endothermic heat of reaction of the synthesis gas reaction. The product stream 4214 of the synthesis gas reaction includes 10,413 metric tons per day of water at 22.8 volume percent, 9,988 metric tons per day carbon monoxide at 14.1 volume percent, 1771 metric tons per day H_2 at 35 volume percent, 21,410 metric tons per day carbon dioxide at 19.3 volume percent, and 3535 metric tons per day methane at 8.7 volume percent.

On page 215, please delete the paragraph beginning on line 29, and substitute therefor:

FIG. 128 is a flowchart of an embodiment of an in situ synthesis gas production process 4510 integrated with a SMDS Fischer-Tropsch and wax cracking process with heat and mass balances. The synthesis gas generating fluid injected into the formation includes about 24,000 metric tons per day of water 4530, which includes about 5,500 metric tons per day of water 4540

recycled from the SMDS Fischer-Tropsch and wax cracking process 4520. A total of about 1700 MW of energy is supplied to the in situ synthesis gas production process 4510. About 1020 MW of energy 4535 of the approximately 1700 MW of energy is supplied by in situ reaction of an oxidizing fluid with the formation, and approximately 680 MW of energy 4550 is supplied by the SMDS Fischer-Tropsch and wax cracking process 4520 in the form of steam. About 12,700 cubic meters equivalent oil per day of synthesis gas 4560 is used as feed gas to the SMDS Fischer-Tropsch and wax cracking process 4520. The SMDS Fischer-Tropsch and wax cracking process 4520 produces about 4,770 cubic meters per day of products 4570 that may include naphtha, kerosene, diesel, and about 5,880 cubic meters equivalent oil per day of off gas 4580 for a power generation facility.

On page 216, please delete the paragraph beginning on line 23, and substitute therefor:

The simulation of H_2 4604 provides a good fit to observed fraction of H_2 4603. The simulation of methane 4602 provides a good fit to observed fraction of methane 4601. The simulation of carbon dioxide 4606 provides a good fit to observed fraction of carbon dioxide 4605. The simulation of CO 4608 overestimated the fraction of CO 4607 by 4-5 percentage points. Carbon monoxide is the most difficult of the synthesis gas components to model. Also, the carbon monoxide discrepancy may be due to fact that the pattern temperatures exceeded 550 °C, the upper limit at which the numerical model was calibrated.

In The Claims:

Please cancel claims 1-4183, 4225-4241, and 4281-5149 without prejudice.

Listed below is a clean copy of amended claims. A marked-up copy indicating the amended sections of the claims is provided in an accompanying document.